NIST Annual Fire Conference 2007

Advanced Fire Service Technologies Program

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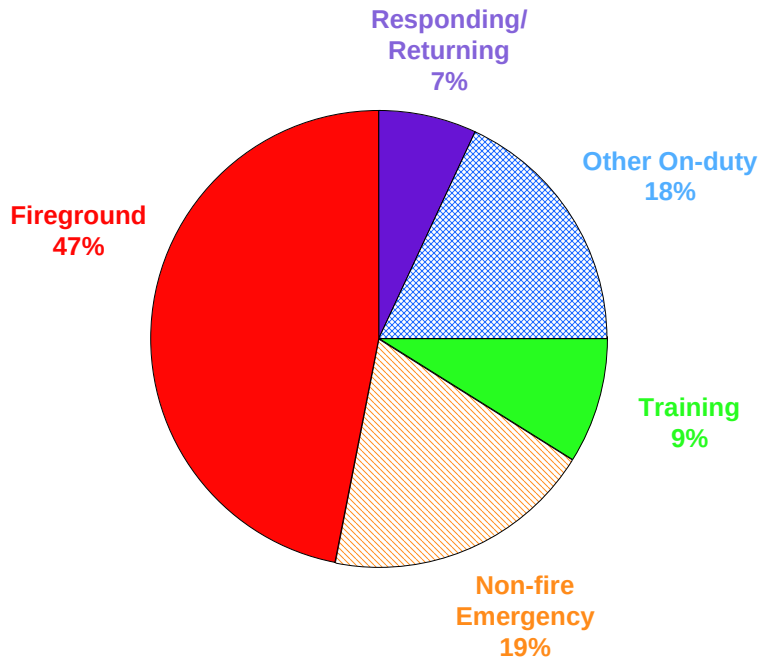
Overview

- **Introduction**
  - **Technology without Standards**
- **AFST Program**
  - **Objectives**
  - **Approach**
- **Projects**
- **Summary**

Why Invest in Advanced Fire Service Technologies ?

- Firefighter Fatalities –
  - 117 in 2004 (USFA)
- Total Injuries –
  - 80,800 in 2004 (NFPA)
  - Fireground – 37,976 injuries



- Magnitude of U.S. Annual Losses ~ $200 billion total cost

Issues- Technology without Standards

- Existing & new technology is being used/developed without adequate metrics or standards to evaluate the performance

- Fire service is learning to exploit
  - existing technologies
    - thermal imaging, positive pressure ventilation
    - performance evaluated in a scientifically sound method
    - technology transferred to the fire service through training programs and fire fighting simulators
  - developing technologies
    - tactical decision aids, training simulators, and improved protective clothing.
    - look ahead to developing innovative technologies and how new technologies can be effectively integrated into existing equipment

AFST Program Objectives

- Provide the science and performance metrics for development and implementation of new technology
- Enable an information rich information environment, fire fighter training tools, and application of innovative new technologies.
- Improve effectiveness and safety of first responders
- Support *Fire Loss Reduction Goal*,
  - facilitate the development & transfer of BFRL research
    - science, metrics, and technology
    - fire fighters, incident commanders, and other first responders.

AFST Program Approach

- Funding does not allow development of performance metrics and testing protocols for all emergency responder equipment

- FY07 funds are prioritized
  - equipment where there are currently no metrics or standards and/or at improving existing metrics and standards
    - thermal imagers
    - hose streams/nozzles
    - respirators

    50%
  - emerging technology with biggest impact is integrated first
    - National Fire Research Agenda Symposium - 50 organizations, including the fire service, IAFC, IAFF, and NVFC, manufacturers, DHS, & USFA
    - fire responder locators
    - tactical decision aids
    - improved protective clothing

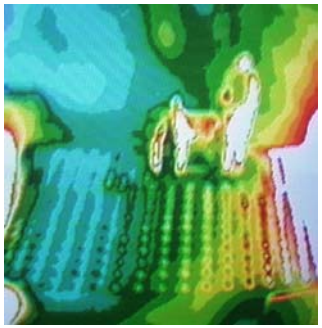
    40%
  - fire fighting simulators and training programs to insure that the above science and technology to transfer to the fire service

    10%

AFST Program Projects

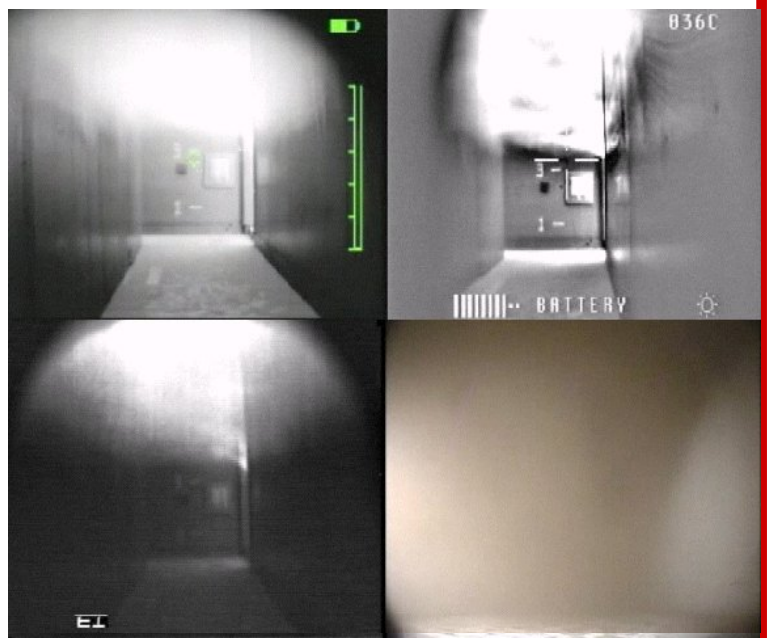
Project	PI
* Thermal Imager Technology	Amon / Bryner
* Characterization of Fire Fighter Respirators	Butler / Bryant
• Fire Fighter Protective Clothing	Gilman / Chin
• Hose Stream Effectiveness	Stroup / Amon
• Research on Hydrogen and Alternate Fuel Hazards to First Responders	Kerber / Bryner
• Monitoring and Metrology Technology for Field Scale Validation Experiments	Stroup / Kerber
* Emergency Responder and Occupant Locator Technology	Bryner / Davis Lytle / Moayeri
* Tactical Decision Aids	Bryner / Davis
• Virtual Fire Fighter Trainer	Forney

Thermal Imager Technology



- Fire service use thermal imagers and infrared cameras
  - Locate “hot spots” or track spread of fire
  - Locate downed occupants and fallen fire fighters
- US market for IR Cameras grows from $81M in 2004 to $189M in 2009
- Currently there is no performance standard for thermal imagers or infrared cameras

- Evaluate performance of thermal imagers and infrared cameras
  - Lab-scale experiments
  - Full-scale field tests
- Develop standard test protocol for evaluating critical performance characteristics
- **Draft Standard (85 pages) submitted to NFPA ESE Committee, but it is a consensus process**



Characterization of Fire Fighter Respirators

- SCBA, Closed-Circuit SCBA, PAPR
- Design data does exist, but based on USAF work from 1960s

- Using computational fluid dynamic models to characterize flow in, out, and around respirator face pieces

- Use laser-based scanner to input
  - Head geometry
  - Respirator geometry

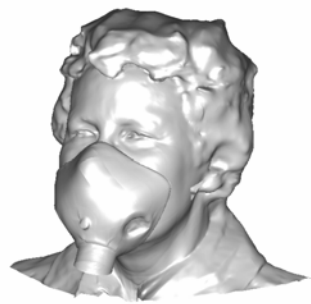
Laser Scanner

Head Scan

+

Mask Scan

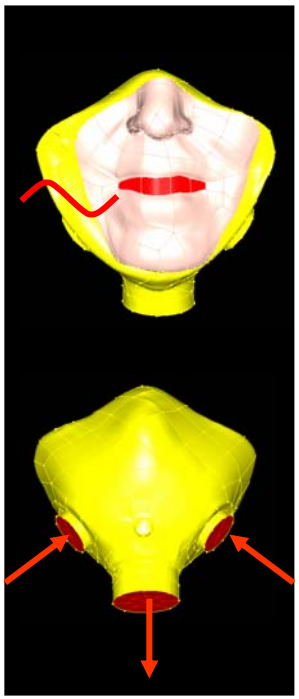
=



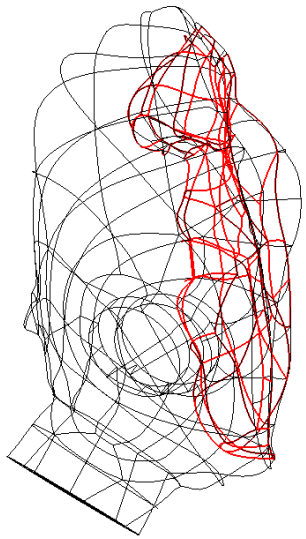
Head & Mask Scan

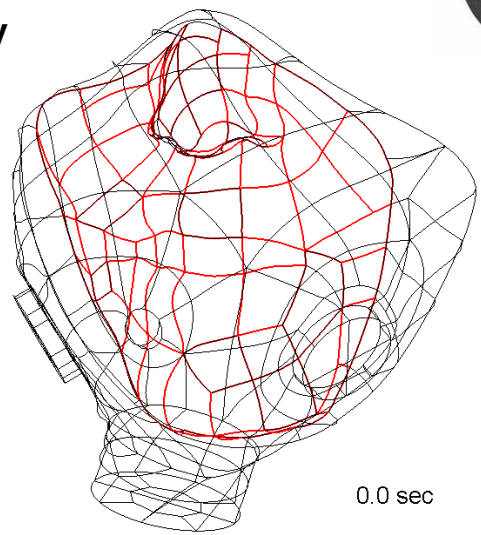
Gas Flow for Breathing Under Work Load

V_T = 1 L
f = 30 breaths/min

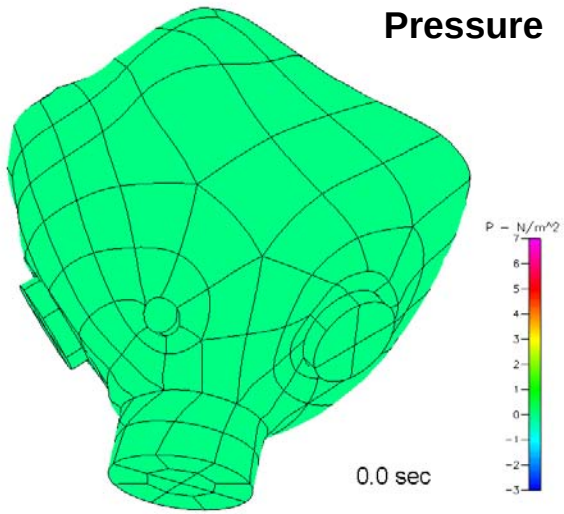


Velocity

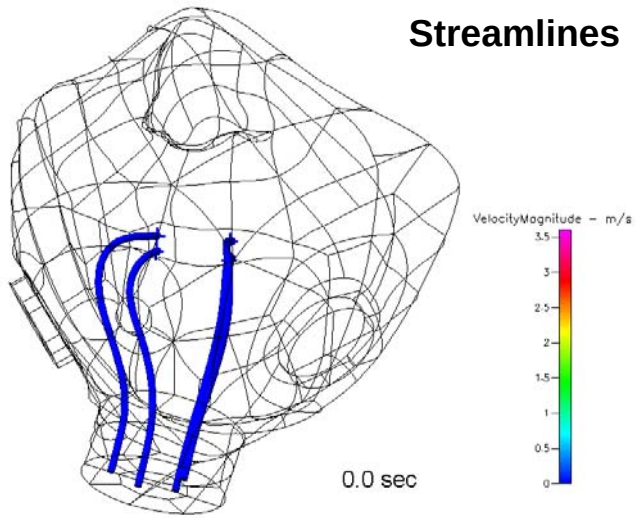




Pressure



Streamlines



Emergency Responder and Occupant Locator Technology

- **Fire fighter / occupant locator systems track first responders and occupants inside structures**

- **Technology must meet the performance needs**
  - **First responders**
    - **Rescue**
    - **Tactical**
  - **Public / building occupants**
  - **No Performance Standards or Testing Protocols**

  - **But, are performance standards really necessary?**
  - **Doesn't industry understand what the fire service needs?**

Emergency Responder and Occupant Locator Technology

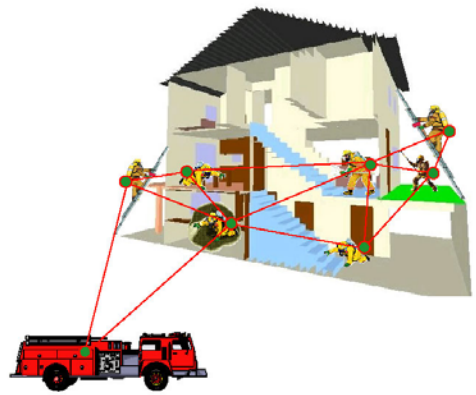
- ***Precision Indoor Personnel Location and Tracking for Emergency Responders Workshop, August 2006***
- **Manufacturers indicated that technology already exists and performs "well"**

Location Resolution under "severe" conditions = 3 foot

Fire Fighter "severe" conditions

Emergency Responder and Occupant Locator Technology

- **Fire fighter / occupant locator systems track first responders and occupants inside structures**
- **Technology must meet the performance needs**
  - **First responders**
    - **Rescue**
    - **Tactical**
  - **Public / building occupants**
  - **No Performance Standards or Testing Protocols**
- **Technology must operate**
  - **Different building types**
  - **Different thermal conditions**
- **Develop standards & testing protocols**
  - **Insure technology consistently performs as needed**
  - **Technology neutral and unbiased standards/protocols**



Locating & Tracking - where or what building type

- **Type I or Fire-Resistive (NFPA)**
  - High rise office, shopping centers, or residential units
  - Reinforced concrete, structural steel (protected)
- **Type II or Noncombustible**
  - Office buildings, warehouses, auto repair shops
  - Metal frame with metal walls, metal frame with masonry walls, masonry walls with metal roof
- **Type III or Ordinary**
  - Office buildings, retail stores, mixed occupancy, apartment buildings
  - Noncombustible bearing walls and combustible roofs
  - Most buildings are of this type
- **Type IV or Heavy Timber**
  - Exterior noncombustible or limited combustible, masonry
  - Interior structural members, walls, columns, floors and roofs are large timbers
  - Common in the New England area
- **Type V or Wood Frame**
  - Single family dwelling, restaurants, retail stores
  - Log, post & beam, balloon, platform, and plank & beam
  - Structural members are wood and exterior walls are combustible

•Developing similar building types for location/tracking

Under what conditions ?

Thermal Class	Maximum Time (min)	Maximum Temperature	Maximum Flux (kW/m^2)
I	25	100 C / 212 F	1
II	15	160 C / 320 F	2
III	5	260 C / 500 F	10
IV	<1	>260 C / 500 F	>10

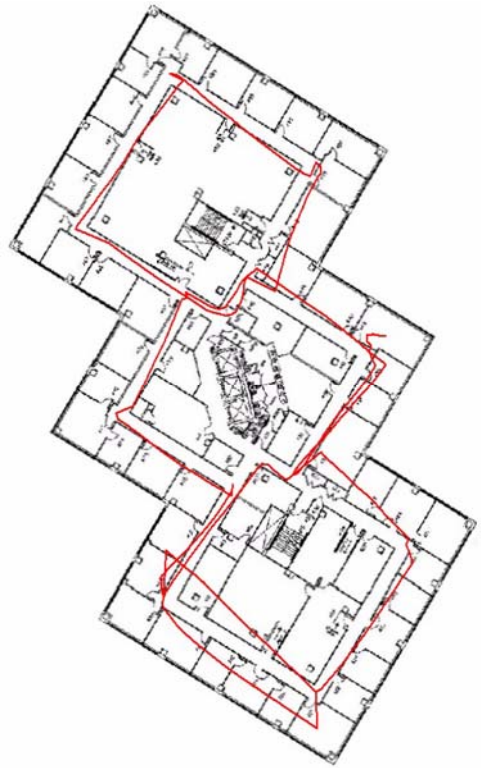
Location & Tracking – Resolution

Residential Scenario

Resolution meters	Location		Escape	
	X-Y Direction	Z Direction	X-Y Direction	Z Direction
100	City Block +/-	10 floors +/-		
10	Front or rear of house	3 floors +/-	Structure +/- (Townhouse)	Floor +/-
1	Room	Floor +/-	Correct Wall	Window or Door
0.1	Location in Room	Correct Floor	Location on wall	Height of window or door

Location and Tracking Performance Standards

- **Role of AFST**
  - **Fundamental Science**
    - **Measurement or metrology**
    - **Signal penetration**
    - **Sensor design**
    - **Combustion Science**
  - **Building performance**
  - **Fire Environment**
  - **Performance Standards and Testing Protocols**
    - **Signal quality**
    - **Sensor interfaces/performance**
    - **Thermal exposure testing**
    - **Network design**
  - **Develop new technology where expertise exists**



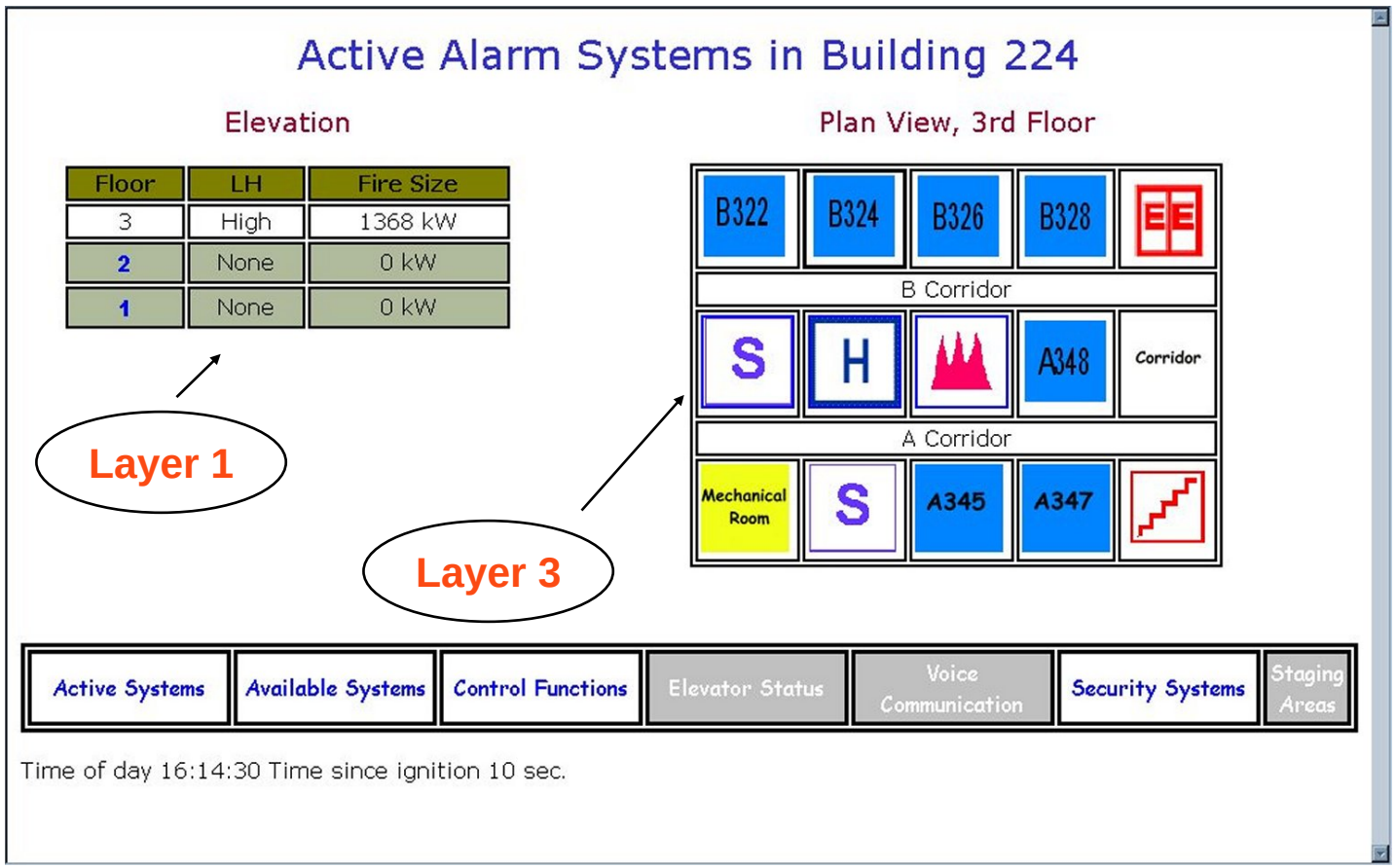
Tactical Decision Aids

- **Provide fire fighters with tactical information**
  - **before arrival - more informed first responders**
  - **better and safer response to emergencies in buildings**

- **Information Rich Environment**
  - **Building sensors – data available at fire panel**
  - **Wireless transfer of floor plans and alarms on apparatus display**
- **Standards**
  - **What is being measured**
  - **How reported to fire panel – fire fighter**

    NFAC Task Group: 2002 NFPA 72 Annex Graphics Annunciator Panel Standard with Icons adopted
- **Training tools**
  - **How to deploy search and suppression teams**

Tactical Decision Aids



Display standard was published as NEMA SB30-2005 to provide standardization of displays for emergency personnel. This display standard was to be included in NFPA 72 at the June 2006 meeting

Tactical Decision Aids

Commercial Implementation (Siemens Fire Finder)

Available Systems

Active Systems

Related Projects

- **Grants/SBIR**
  - **Structural Collapse** Harvey Mudd College
  - **Fire Fighter Locator** Summit Safety
  - **Fire Fighter Interface** U Texas San Antonio
  - **Positive Pressure Ventilation** U Texas Austin

- **Other Agency Funding**
  - **PASS Devices** **USFA**
  - **IR Camera Standards** **USFA**
  - **Burn Pattern Analysis** **OLES & DHS**
  - **Passive Cooling Systems** **DHS**
  - **RFID Performance Standards** **DHS**
  - **RF Linked PASS Devices** **DHS**
  - **Technology Transfer** **USFA**
  - **Structural Collapse** **OLES**
  - **Locator/Tracker** **ATP**

Summary

AFST Program

- **Gets BFRL research directly into hands of**
  - Fire service
  - Fire protection engineers
  - Fire equipment manufacturers
- **Critical role in providing science-based**
  - Performance metrics
  - Standard testing protocols
- **Plays a leadership role**
  - Technology and standards for transfer of emergency information from buildings to fire service
- **Improve the safety and effectiveness of fire fighters**
  - Reduction of fire related fatalities and injuries
  - For both fire fighters and building occupants
  - Reduction in losses due to fires

Hose Stream Effectiveness

- **Effectiveness for suppressing real fires**
  - **never been characterized**
  - **performance metrics not developed**
  - **no testing standards exist**

- **Types of hose streams**
  - **straight stream**
  - **Fog**

- **Full-scale experiments**
  - **in the open and in enclosures**
  - **flow rate, reach, and pattern**

Location & Tracking - Resolution

Industrial Scenario -

Resolution meters	Location		Escape	
	X-Y Direction	Z Direction	X-Y Direction	Z Direction
100	Building +/-	10 floors +/-		
10	Section of Bldg	3 floors +/-	Section of Bldg	Floor +/-
1	Room	Floor +/-	Correct Wall	Window or Door
0.1	Location in Room	Correct Floor	Location on wall	Height of window or door